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MESOZOIC CHANGES IN THE FAUNAL GEOGRAPHY OF CALIFORNIA.

CONTENTS.

INTRODUCTION.

THERE is probably no region where the successive faunas have been a genetic series. With each new set of rocks species, genera, families appear without local forerunners and disappear without leaving local descendants. Thus the distribution of

genera varies greatly in successive periods. These changes have been due to migration; each rising of a seacoast, or transgression of sea on land areas, or connection of basins that before were separated, has added to the confusion of faunas, bringing in new elements, while many of the old were forced to migrate, or else were unable to survive the new conditions and increased natural competition with vigorous immigrants.

Marine invertebrates migrate chiefly through their young, and along shore lines, where the successive generations can find the same conditions suitable to their perpetuation, and the young are especially sensitive to changes in temperature and food-supply. Therefore marine currents along continental borders are very favorable to migration, since by them the same conditions necessary for life are spread far out of their usual range.

If the naturalist would trace out the life history of genera and species, he must not confine his studies to a single region, for there the history is made up of disconnected episodes. He must seek the regions from which the faunas came and follow out their migrations into regions to which they departed, must find out what regions contributed certain new elements to the population and must learn the order of appearance of a fauna in different parts of the earth. In this way alone can he get a true idea of the changes which forms have suffered, and the reason of these changes, the mutual working of the laws of natural selection and adaptation to surroundings. In this way, too, he can get a true history of the inhabitants of the earth, and of the changes in physical geography at various periods, the primary object of geologic investigation.

The study of the faunal relations of the various series of sedimentary rocks of California has proved exceedingly interesting and has thrown much light on past changes in physical geography. Some of the facts obtained seem to conflict with the theory of the permanency of continental plateaux and oceanic troughs.

The writer has, therefore, undertaken to outline the faunal relations which California had with various regions during differ-

ent periods of geologic history, and the probable changes in physical geography that accompanied and caused this shifting of relations. The Mesozoic era has been taken as a basis because the faunas of that time are better known, and because the physical geography of that time has been better worked out all over the earth. But the changes which preceded the Mesozoic era will also be outlined as far as they are known. And since California is intimately connected with other regions of the West Coast, these regions will also be considered in so far as they concern California.

PRE-CARBONIFEROUS RELATIONS.

Cambrian and Silurian.—The Cambrian and Silurian of California, as described by Professor C. D. Walcott[1] in the papers cited below, are too little known for any opinion about them to be decisive; they are, however, probably like the Cambrian and Silurian as it is known in Nevada and the West in general.

Devonian.—In California the Devonian is little known, having been described by J. S. Diller and Charles Schuchert[2] from only a few places in Shasta and Siskiyou counties, and the forms that occur there give little clue to the affinities with other regions. But from the study of the faunas of other parts of America we get some light on the geography of the Devonian.

The work of Dr. A. Ulrich[3] has made it clear that during the Lower and Middle Devonian the faunas of North America were closely related to those of Bolivia, Brazil, the Falkland Islands, and South Africa, but that they were different from those of Europe. But Professor H. S. Williams[4] has shown that at the beginning of the Upper Devonian in North America there came in many species whose ancestors are not found in the Middle Devonian of that region. This fauna, however, is closely related

[1] Am. Jour. Sci., III. Series. Vol. XLIX., pp. 141–144, and Bull. Geol. Soc. Amer., Vol. III., p. 376.

[2] Am. Jour. Sci., III. Series, Vol. XLVII., pp. 416–422.

[3] Beiträge zur Geol. und Pal. von Südamerika, I. Paläozoische Versteinerungen aus Bolivien.

[4] Bull. Geol. Soc. Amer., Vol. I., Cuboides Zone and its Fauna, and Proc. A. A. A. S., 1892, Sec. E., Address; Scope of Paleont. and its Value to Geologists.

to that of Europe and Asia while quite different from that of the southern regions.

This striking change in the faunal relations of North America means something more than a mere migration; it means that in Lower and Middle Devonian times some barrier cut off the European and Asiatic faunas from those of America, and that in the Upper Devonian this barrier was removed while one was interposed between the northern and the southern regions. Professor W. Waagen[1] has shown that this continued during the Carboniferous and Permian.

CARBONIFEROUS FAUNAS.

Lower Carboniferous.—In a previous paper[2] the writer has shown that the Lower Carboniferous fauna of California was derived directly from the preceding Devonian, since so many species that in the Mississippi Valley or eastern region would be considered characteristic of the Devonian still survive. This survival has been used by Professor H. S. Williams,[3] and the writer,[4] to show that the reappearances of older forms in younger rocks have been due to migrations consequent upon the shifting of physical barriers.

Affinities of the fauna.—The Lower Carboniferous, or Baird Shales, fauna of California is intermediate in character, as it is in geographic position between the eastern American and the Russian and Asiatic. It differs from the typical American fauna in the survival of so many Devonian types and the presence of some Eurasian elements. It belongs to the zone of *Productus giganteus* or the lower part of C_1 of the Russian section.

Upper Carboniferous.—The Upper Carboniferous fauna of California seems to have been developed directly out of older species in the same region, since there is known no complication of elements brought in by the migration from outside the Pacific Car-

[1] Palæontologia Indica, Salt Range Fossils, Geological Results.

[2] JOUR. GEOL., Vol. II., No. 6, The Metamorphic Series of Shasta County, California.

[3] Am. Jour. Sci., III. Series, Vol. XLIX., pp. 94-101.

[4] JOUR. GEOL., Vol II., p. 198, and Vol. II., p. 598.

boniferous region. Again here we see the intermediate characteristic between the eastern American and Eurasian faunas, but the affinities are closer with the latter.

The McCloud limestone corresponds to the upper part of C_1, and the lower part of C_2 of the Russian section. The upper part of the McCloud limestone is, therefore, homotaxial with the zone of *Omphalotrochus whitneyi*, Meek. This species was first described from the McCloud limestone, but has been found in eastern Russia near the top of C_2 in such large numbers as to give name to the zone.

Artinsk beds.—The argillites above the McCloud limestone are the equivalents of the Robinson beds of the Taylorsville region and of the Little Grizzly creek beds of Plumas county. These are probably homotaxial with the top of C_2, and the lower part of the Artinsk stage of Russia. They contain the following species closely related to forms of the Russian Artinsk stage, and the Productus limestone of the Salt Range in India :

Marginifera conf. *splendens*, Norwood and Pratten.
Productus conf. *cora*, d' Orbigny.
" conf. *scabriculus*, Martin.
" conf. *spiralis*, Waagen.
" group of *P.*, *abichi*, Waagen.
Streptorhynchus conf. *pelargonatus*, Schlotheim.
Camarophoria conf. *purdoni*, Davidson.
Dielasma elongata, Schlotheim.
Spirifer interplicatus, Rothpletz.
S. (*Reticularia*) *lineatus*, Martin.
S. wynnei, Waagen.

In addition to some of these, the Robinson horizon of Plumas county contains a very long slender *Fusulina* that agrees closely with *F. longissima*, Möller from the Salt Range.

Of the above mentioned species *Marginifera* conf. *splendens* is the form usually identified with *Productus longispinus*, Sowerby in the Western Upper Carboniferous. *Productus* conf. *spiralis* is only a mutation of *P. semireticulatus*, Martin; *Spirifer wynnei* is a modification of *S. striatus*. Thus this fauna stands to the Carboniferous forms as mutations, showing only a slight difference in

age. It appears quite probable that they belong to the Artinsk stage, but it is also quite possible that they are homotaxial with the uppermost Coal Measures, because at the top of C_2 of the Russian Coal Measures many Permian species appear.

The inhabitants of the Eurasian and the North American Carboniferous seas belong to one type, the northern of Waagen,[1] and were separated from the southern regions.

POST-PALÆOZOIC REVOLUTION.[2]

Towards the end of the Carboniferous the greater part of the North American continent was raised above water; this revolution, or revolutions nearly contemporaneous with it, was very widespread, so that the break between the Palæozoic and Mesozoic has never been bridged over. Quite recently, however, Professor W. Waagen[3] has described from northwest India a set of fossils younger than the latest Permian and older than the oldest known Trias. But even here these forms are continuous with the Trias, but separated from the Permian by a break in life. In the West, therefore, the Triassic species are not descendants of the preceding local Palæozoic forms, but are foreigners, brought in by migration from regions as yet unknown. This itself, if we had no other proof, would be sufficient evidence that there must have been great stretches of continental margin where these faunas could develop, and that these breeding grounds have been mostly obliterated by the sea, so that we find their remnants in only a few places, such as the Salt Range in India.

TRIASSIC FAUNAS.

Lower Trias.—Even if we do not know where to look for the ancestors of the Triassic animals, we know well where to look for their contemporary kinsfolk. In California as yet no Lower Triassic fossils have been described, but rocks are here that are probably of that age, so that the finding of fossils is only a question of time.

[1] Salt Range Fossils, Geol. Results, p. 239.

[2] See TSCHERNYSCHEW, Mem. Com. Geol. Russie, Vol. III., No. 4, p. 364.

[3] Jahrbuch. K. K. Geol. Reichsanstalt Wien, 1892, Vol. XLII., Vorläufige Mittheilung ueber die Ablagerungen der Trias in der Salt Range.

But near by, in southeastern Idaho, are found Lower Triassic[1] fossils, of which the most characteristic are *Meekoceras gracilitatis*, White, *M. mushbachianum*, White, and *Xenodiscus aplanatus*, White Very closely related forms have been described from the Salt Range of India by Waagen,[2] and from northern Siberia by Mojsisovics,[3] and from the Himalayas by Griesbach.[4] It is clear then that the post-Palæozoic revolution had not cut off the West Coast region from direct connection with the Indian and Arctic provinces. But these two provinces were probably cut off from the Mediterranean province, since it has been shown by Mojsisovics[5] that during Lower Triassic time *Tirolitinæ* were common, *Dinaritinæ* rare, but *Meekocerata* almost unknown in the Mediterranean region; while in the Arctic province there were no *Tirolitinæ*, but many *Dinaritinæ* and *Meekocerata*. Also Waagen[6] has recently shown that the same thing is true of the Salt Range and Himalayan Lower Triassic faunas.

The Idaho beds were, therefore, deposited on the extreme eastern border of a sea that stretched from the Salt Range eastward to America, and northwards to Siberia. And for the Lower Trias alone the Arctic-Pacific Trias province of Mojsisovics will hold good. In this province somewhere we have to seek for the ancestors of the *Ceratitidæ*, which Mojsisovics[7] says will be found among some of the *Meekocerata*, while Karpinsky[8] thinks it probable that the *Meekocerata* descended from the goniatite stock *Prolecanitidæ*.

Middle Trias.—Rocks of the Muschelkalk series are only doubtfully known in California, but a comparatively rich fauna of this age has been described from the Star Peak range in

[1] C. A. WHITE: Twelfth An. Rep. U. S. Geol. Surv. Terr., Part I., pp. 105–118.

[2] Pal. Indica, Salt Range Fossils, I. Productus Limestone Fossils, Cephalopoda.

[3] Mém. Acad. Impér. Sci. St. Pétersbourg, Series VII., Tome XXXVI., No. 5. Arktische Triasfaunen.

[4] Records Geol. Surv. India, Volume XIII. Part I., 1880.

[5] Arktische Triasfaunen, p. 149.

[6] Jahrb. K. K. Geol. Reichsanstalt Wien, Vol. XLII., 1892, pp. 384–5.

[7] Abhandl. K. K. Reichsanstalt Wien, Vol. VI., Part II., Cephal. Hallst. Kalke II. Part, p. 7.

[8] Ammoneen der Artinsk-Stufe, p. 43.

Nevada, by F. B. Meek.[1] This fauna has been shown by Mojsisovics[2] to possess certain elements unknown to the Arctic Lower and Middle Trias; these are *Trachyceras*, *Acrochordiceras*, *Eutomoceras*, *Arcestes*, and *Orthoceras*. But of these *Acrochordiceras*, *Arcestes* and *Orthoceras* are present in the Muschelkalk of the Mediterranean Trias province. *Trachyceras* is the culmination of the stock of *Tirolitinæ*, which according to Mojsisovics are wholly lacking in the Arctic Lower and Middle Trias, but are common in the Mediterranean province; to the latter region, then, we must look for the derivation of the Western *Trachycerata*.

Eutomoceras is a member of the *Tropitidæ*, which are unknown in the Mediterranean province during Middle Trias; their remote relative, *Sibirites*, is common in the Lower Trias of Siberia, and may have been an ancestral stock of the *Tropitidæ*, whose more remote progenitors, according to Mojsisovics,[3] are probably to be found among the *Gastriocerata*, which group is not uncommon in the American Upper Carboniferous.

We see, then, among the Western Middle Trias forms a considerable infusion of Mediterranean elements, showing that intermigration between the two regions has begun, but that intimate connection with the Arctic province still exists.

Upper Trias.—In California rich faunas of the Upper Trias have been described from Plumas county by W. M. Gabb[4] and Professor A. Hyatt,[5] and from Shasta county by the writer.[6] These faunas show an intimate connection with the Himalayan and Mediterranean provinces, but only a few species in common with the Upper Trias described from British Columbia by J. F. Whiteaves.[7]

The Upper Trias, Noric and Karnic, of Plumas and Shasta counties has yielded the following species thought to be

[1] Geol. Exploration Fortieth Parallel, Vol. IV.

[2] Arktische Triasfaunen, p. 148.

[3] Abhandl. K. K. Geol. Reichsanstalt Wien, Vol. VI., Part II., second half, p. 7.

[4] Palæont. Calif., Vol. I.

[5] Bull. Geol. Soc. Am., Vol. III., pp. 395–412.

[6] JOUR. GEOL., Vol. II., No. 6. Metamorphic Series Shasta County.

[7] Geol. Survey Canada. Contrib. Canad. Pal., Vol. I., Part II., pp. 127–149.

identical with, or nearly related to, forms described from the Tyrolean Alps:

Eutomoceras sandlingense, Hauer.
Isculites conf. *obolinus*, Dittmar.
Juvavites Group of *J. ehrlichi*, Mojsisovics.
Sagenites conf. *herbichi*, Mojsisovics.
Tropites conf. *dittmari*, Mojsisovics.
" aff. *marii*, Mojsisovics.
" conf. *sellai*, Mojsisovics.
" *subbullatus*, Hauer.
" *torquillus*, Mojsisovics.
Badiotites aff. *eryx*, Mojsisovics.
Polycyclus henseli, Oppel.
Trachyceras conf. *aon*, Muenster.
" aff. *archelaus*, Laube.
Tirolites (*Metatirolites*) *foliaceus*, Dittmar.
Nannites conf. *spurius*, Muenster.
Nautilus triadicus, Mojsisovics.
Halobia lommeli, Wissmann.
" conf. *rugosa*, Mojsisovics.
" *superba*, Mojsisovics.
Monotis salinaria, Schlotheim.

Many of these species also occur in the Himalayas, although until the completion of Mojsisovics' monograph on the Himalayan Upper Trias no exact comparison with that region is possible.

The above list shows that in California, as in the Himalayan and the Mediterranean provinces, with the beginning of the Karnic stage of the Upper Trias there came in from some unknown region a swarm of *Tropitidæ*. It is interesting to note that during this period the Salt Range fauna seems to have preserved its Arctic character, and to have been cut off from the sea in which the faunas of the Mediterranean, the Himalayan and the Californian provinces lived.[1] Again here we see an indication of a great change in physical geography, that has left no other record than the incursion of an exotic fauna.

JURASSIC FAUNAS.

Lias.—A marked hiatus separates the Lias of California from the Trias, as is the case everywhere else; the *Tropitidæ* and

[1] W. WAAGEN: Jahrb. K. K. Geol. Reichsanstalt Wien, Vol. XLII, 1892, p. 385.

Ceratitidæ have died out, and again a new fauna comes in from unknown regions. The lower Lias of California and Nevada, according to Professor A. Hyatt,[1] is characterized by the presence of *Arietidæ* of European habitus although not identical with European species.

The Lias[2] is typically developed over western Europe, and as far to the southeast as the Caucasus Mountains, but wholly unknown in eastern Europe, eastern Africa and continental Asia.

In the work cited, Neumayr has shown from the distribution of fossils and sediments during the Lias that then eastern Europe, nearly all Africa and Asia were above water, since Jurassic land-plants are found over much of this area; but on Japan is found Lias of European type.

Dr. O. Behrendsen[3] has recently described from the Argentine Republic lower Lias, with typical European species of *Arietidæ* and *Amaltheidæ*. The same type of Lias, with *Arietites geometricus*, Oppel, and *A. longicellus*, Quenstedt, has been described by Dr. A. Rothpletz[4] from Timor in the Indian Ocean. These species could not have migrated to or from Europe by the western way, since this was blocked by the continental mass at the junction of Europe, Asia and Africa. They along with the American species could only have migrated by the eastern way through the "Central Mediterranean Sea."[5] In this way we have in the Lower Jura of California a central European type of fauna.

Middle Jura.—The fossils of the Californian Middle Jura are too little known for us to be able to speak with certainty about their faunal relations, but the few species that have been described by Professor A. Hyatt[6] are probably of central European type.

[1] Bull. Geol. Soc. Am., Vol. V. Trias and Jura in the Western States.

[2] M. NEUMAYR: Denkschr. K. Akad. Wiss. Wien., Vol. L, 1885, Geograph. Verbreitung der Juraformation.

[3] Zeitschr. Deutsch. Geol. Gesell., 1891, p. 371.

[4] Palæontographica, Vol. XXXIX., p. 97.

[5] M. NEUMAYR: Geographische Verbreitung der Juraformation.

[6] Bull. Geol. Soc. Am., Vol. III., pp. 395–412.

Upper Jura.—The Upper Jura of California has been described from Plumas county and from the Mariposa formation of the Gold Belt by F. B. Meek in Vol. I. of the "Palæontology of California;" by Professor Hyatt,[1] and by the writer.[2]

The fossils described by Professor Hyatt from the Callovian and Corallian of Plumas county are of rather indecisive character, but seem to have their nearest affinities with central European species. This makes it probable that throughout the Callovian and part of the Oxford these waters were still connected with the central European. But at this same time there existed in the region of the Black Hills of Dakota and the Rocky Mountains a basin that contained a different fauna, and according to Professor Hyatt[3] was separated from the Californian basin. This central basin contains what Neumayr[4] has shown to be a decidedly Boreal fauna. In the paper referred to, Neumayr divided the Jura of the northern hemisphere in three distinct types, equatorial, temperate and Arctic. The Arctic or northern type occurs chiefly in Russia, and is characterized by the prevalence of *Cardioceras* and *Aucella*, and the absence of reef-building corals. Neumayr[5] has shown that the Black Hills Jura is a southern extension or bay of the Arctic sea.

It therefore becomes probable that during Oxford times the California area was still connected directly with the central European waters by way of the "Central Mediterranean Sea," and that the Black Hills basin was cut off from this, but connected with the Boreal sea of Russia.

Transgression of Upper Malm.—It has long been known that in Europe in the Middle Jura the sea began to transgress eastwards over the land until in the Upper Jura or Malm all eastern Europe and nearly all Asia were under water. This has been described by Neumayr[6] as one of the most striking events in

[1] Bull. Geol. Soc. Am., Vol. III., pp. 395–412; and Vol. V., pp. 395–434.

[2] Bull. Geol. Soc. Am., Vol. V., "Age of the Auriferous Slates of the Sierra Nevada."

[3] Bull. Geol. Soc. Am., Vol. III., p. 410.

[4] Denkschr. K. Akad. Wiss. Wien., 1883, pp. 301–302.

[5] Loc. cit.

[6] Geographische Verbreitung Juraformation, pp. 126–129.

geologic history, and one extending all over the northern hemisphere. But it becomes probable that while Eurasia was sinking, North America was rising, and that the eastward connection with European waters was cut off, for with the Kimmeridge there came in a fauna that no longer had any affinities with the central European, but rather with the Russian. This fauna has been described in the above mentioned papers by F. B. Meek, Professor A. Hyatt and the writer, from the Mariposa formation of the Gold Belt of California, also by Professor Nikitin[1] from San Luis Potosi in Mexico.

This type is characterized by the presence of *Cardioceras* of the group *C. alternans* and *Aucella* allied to *A. pallasi* and *A. bronni.*

There was, therefore, an elevation of a large part of America and also a transgression of the Boreal or Russian sea along the west coast as far as Mexico. This movement was correlative with the great Jura transgression of Eurasia.

It is a remarkable fact that this same fauna is found in the Spiti shales on the north side of the Himalaya Mountains while the Upper Jura of Kutch on the south side is of decidedly central European character. Neumayr[2] considers the Himalayan Jura a southward prolongation of the Boreal sea and the Kutch formation a prolongation of the central Mediterranean which also sent down a long gulf to Mombassa on the east coast of Africa. These African and Indian waters were separated from the western American by the ancient Australo-Asian continent, over which no marine Jura occurred, but widespread fresh-water deposits with Jurassic plants. Remains of this continent are still seen in Australia, New Zealand, and the submarine plateau on which are the islands that separate the Pacific from the Indian Ocean.

During all this time the Upper Jura of South America, as described by Dr. O. Behrendsen,[3] retained its central European

[1] Neues Jahrb. Min. Geol. und Pal., Band 2, 1890, p. 273.

[2] Geographische Verbreitung der Juraformation, pp. 109–117.

[3] Zeitschr. Deutsch. Geol. Gesell., 1891, pp. 369–420, and 1892, pp. 1–42.

character, having many species in common with that region, but being entirely cut off from the Californian.

CRETACEOUS FAUNAS.

Knoxville.—At the beginning of the Lower Cretaceous of California, as in the Upper Jura, we find that the closest affinities with foreign faunas are with the Volga stage of Russia. These beds and their faunas have been described by W. M. Gabb in the Palæontology of California, by J. S. Diller and T. W. Stanton,[1] and a similar fauna has been described from Queen Charlotte Islands by J. F. Whiteaves.[2] In the papers cited it has been shown that of the Knoxville fauna the following species are nearly related to Russian forms: *Aucella piochi*, Gabb, very near *A. mosquensis*, Buch; *A. crassicollis*, Keyserling, probably identical with the Russian species; *A. piochi*, var. *ovata*, possibly identical with *A. terebratuloides*, Lahusen; *Olcostephanus* aff. *discofalcatus*, Lahusen. And besides these there occurs *Hoplites* aff. *ambligonius* N. and U. These are sufficient to show a close faunal connection with Russian waters.

In addition to the species mentioned there are others of a Tithionan aspect, so that we have certainly the lowest Cretaceous and possibly the top of the Jura. Mr. Diller, in his various papers, has shown that the lowest Knoxville beds are separated from the highest Jura by a decided unconformity, but this does not represent any long time interval, and is not accompanied by any great change in life. The faunal geography was the same as at the close of the Mariposa epoch, and no new elements had come in; the change was due to development and intermigration between this region and Russia. Rocks of this age are unknown in India, so of the relation with southern Asia nothing can be said.

Horsetown.—In the Horsetown, or Gault, fauna it is seen that a great change has taken place; these beds lie conformably on the Knoxville, yet the Russian elements have nearly all died out,

[1] Bull. Geol. Soc. Am., Vol. IV., pp. 205–224; Vol. IV., pp. 245–256; Vol. V., pp. 435–464.

Geol. Survey Canada, Mesozoic Fossils, Vol. I., Parts I. and III.

and a new fauna has come in, of which the majority could not have developed out of Knoxville forms, but are of southern type. This fauna is found in southern India, where it has been described by Stoliczka in the Palæontologia Indica.

The Horsetown[1] beds of California have yielded the following species thought to be identical with species from the Ootatoor group (Gault) of southern India:

Lytoceras sacya, Forbes.
Schloenbachia inflata, Sowerby.
Haploceras beudanti, Brongniart.

Besides these *Acanthoceras mamillare*, Schlotheim, unknown in India, is also found in the Horsetown.

The lower beds of Queen Charlotte Islands have yielded the above Indian species, and in addition to them several others as yet unknown in California. These species are nearly all also found in the Gault, Lower Cretaceous, of central Europe.[2]

Thus the Californian fauna has lost entirely its Boreal aspect since there was no longer any connection with Russia; rocks of this age are little known in that part of Europe.

Upper Cretaceous — Chico. — It has been shown by J. S. Diller and T. W. Stanton, in the papers cited above, that the Chico rocks and the Chico fauna are simply a continuation of the Horsetown. No Chico species are referred to European or Indian species, but many have near relatives in those regions. But the connection was still kept up, for the Upper Cretaceous of Vancouver Island still shows the presence of Indian types. On the other hand there seems to have been little connection with the interior region.

During the Cretaceous there was a revolution in the West, for in California the uppermost Cretaceous and the lowest Eocene are lacking. But we do not know how extensive this was, since

[1] See the papers of J. F. WHITEAVES, J. S. DILLER and T. W. STANTON cited above.

[2] A paper by Mr. F. M. ANDERSON on Some Cretaceous beds of Rogue River Valley, Oregon (this number JOURNAL GEOLOGY), materially increases the list of Indian species on the West Coast, but all the facts stated about the Cretaceous were taken wholly from previously published works on the subject.

the Eocene of Asia is too little known for any comparison with the California Eocene to have value.

The distribution of Upper Cretaceous fossils on the West Coast seems to conform to the climatic zones[1] as they existed in Africa and Europe, California and British Columbia having the central European type, while Lower California and Mexico have the equatorial type with *Hippurites* and *Buchiceras*.

After the Cretaceous, and indeed before the end of it, the faunas seem to have been limited closely to their present ranges.

SUMMARY.

From the foregoing pages the following conclusions are reached:

At the beginning of the Upper Devonian some widespread disturbance occurred, opening up connection between the American and Eurasian seas.

The Lower Carboniferous fauna of California was developed directly out of Devonian predecessors with the addition of some Eurasian elements by migration.

The Upper Carboniferous fauna was developed out of that of the Lower Carboniferous, but still with intermigration with the Russian and Asiatic regions, so that the California Carboniferous resembles the Eurasian even more than it does that of the eastern United States.

The Lower Triassic fauna of the West is entirely foreign, having migrated in from unknown regions, but having reached nearly simultaneously the western part of America, the Salt Range in India, and northern Siberia, but having been cut off from central Europe.

The Middle Trias of the West already begins to show relationships to the Mediterranean province of Europe, showing a connection in that direction, while the similarity to the faunas of the Arctic Trias province is disappearing.

In the Upper Trias the nearest faunal affinities are with the Himalayan and the Mediterranean provinces.

[1] M. NEUMAYR: Klimatische Zonen während Jura und Kreide Zeit.

In the Lower and Middle Jura there was no connection with European waters through the Pacific region, but rather through the Atlantic or "Central Mediterranean Sea" of Neumayr, bringing a central European fauna.

Near the beginning of the Upper Jura this connection with European waters was cut off, and one established with those of Siberia and northern Europe, bringing in a Boreal fauna.

This same connection was continued through part of the Lower Cretaceous, giving a Boreal fauna to the Knoxville.

Near the beginning of the Gault, connection with the Boreal sea of Russia was cut off, and communication established with southern India and through that country with central and southern Europe, bringing in a warm-water fauna. This connection existed during the greater part of the Cretaceous, but after this time the faunas are confined much more closely to their present ranges, although even today many of our living and Tertiary mollusca are found in Japan.

These changes in faunal geography are too widespread and easily correlated over great areas to be charged to mere mountain-making; they must rather be of the nature of continental uplift and subsidence. A study of these changes will throw light on the problem of the extinction of faunas and explain the great poverty of certain beds, in which the conditions for life seem favorable.

The fauna of California has not been a genetic series, but rather a succession of independent faunas, derived by migration from various parts of the earth, complicated by the mixture with the products of local development. Therefore the student that would intelligently study the genesis and history of this fauna must not neglect the fossil records of any region, since all may have contributed some elements to this complex assemblage of forms.

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